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APPLICATION FOR LETTERS PATENT

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SYSTEM FOR FLUSHING AT LEAST ONE INTERNAL SPACE OF AN OBJECTIVE

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System for flushing at least one internal space of an objective

BACKGROUND OF THE INVENTION:

1. Field of the invention

0001   The invention relates to a system for flushing at least one internal space of an objective.

0002   More specifically the invention relates to a system for flushing at least one internal space of a microlithographic projection exposure objective for manufacturing semiconductors.

2. Description of the invention

0003   It is generally known to seal off objectives, in particular exposure projection objectives for manufacturing of semiconductors, from the surroundings and to flush the internal space(s) of the objective with the aid of a flushing gas in order to avoid contamination from outside, the operation being performed with a slight overpressure.

0004   Because of the chemical stability of inert gasses, it has already been proposed to carry out flushing with the aid of such a gas.

0005   With regard to the general prior art, reference may be made in this context to US-A 5,157,555, in which it has been proposed to undertake a correction of spherical aberrations by means of a variable air gap between neighboring surfaces.

0006   US-A 6,252,648 B1 describes an exposure apparatus in microlithography, and an exposure method, a closed

space being introduced in an objective in order to avoid contamination and to clean a mixture of an inert gas and oxygen.

0007   US-A 4,871,237 has proposed improving the optical imaging accuracy of an objective by changing the barometric pressure of an internal space of an objective. Various gasses and gas mixtures are proposed as medium for the internal space in order to change the refractive index in the gas mixture.

0008   Flushing with the aid of an inert gas entails comparatively high costs which, although entirely acceptable during the operation of an objective, entail a substantial cost outlay in the phase of adjusting and mounting. If it is now desired to operate an objective in this phase of mounting and adjustment with the aid of the very cost-effective flushing gas of air, its imaging is calculated for flushing with air. If, in its final proper use, however, the objective is to be flushed with the very much more expensive inert gas, the problem arises that these gasses have a refractive index which deviates substantially from the refractive index of air. This results in aberrations which would lead to malfunctioning of the objective.

0009   It is therefore the object of the present invention to create a system for flushing at least one internal space of an objective, on the one hand the use of inert gasses for flushing being rendered possible, but on the other hand no changed refractive index being introduced.

SUMMARY OF THE INVENTION

0010   This object is achieved according to the invention by means of a system for flushing at least one closed internal space of an objective, the flushing being performed by mixing at least two inert gasses in such a

way that the refractive index resulting therefrom
corresponds at least approximately to the refractive
index of air.

0011   According to the invention, inert gasses are now
intermixed in such a way that the refractive index
resulting therefrom corresponds to the refractive index
of air. The result of this is that the objectives can
firstly be operated with the very favorable flushing
gas of air and being adjusted and mounted. Not until
the final adjustment and/or the final proper use of the
objectives in situ is the change then made to flushing
with an inert gas mixture. In this case, there is the
advantage of chemical stability over a long operating
period. Aberrations which lead to malfunctioning of the
objective are reliably avoided by the adaptation of the
refractive index.

0012   Experiments have shown in practice that the object set
can be achieved very effectively in an economical way
when, in the case of the use of two inert gasses, use
is made of nitrogen and helium as the gasses, nitrogen
constituting the main constituent with 95 to 99.5% by
volume, preferably even 98.8%, and this mixture can be
used to create in conj .ction with helium a refractive
index which largely corresponds to that of air.

0013   Of course, yet further inert gas mixtures are possible
with other gas compositions within the scope of the
invention.

0014   By means of an appropriate adaptation or mixing ratio,
it is also possible if necessary specifically to set
refractive index changes for the purpose of correcting
aberrations which occur.

0015   This means that, if necessary, objectives already used
in practice can also be improved by means of this gas
mixture.

BRIEF DESCRIPTION OF THE DRAWINGS

0016   An exemplary embodiment of the invention is described
        below in principle with the aid of the drawing, in
        which:

        Figure 1   shows a projection objective of a projection
                   exposure machine for semiconductor
                   lithography, and

        Figure 2   shows a schematic of a projection exposure
                   machine having a projection objective
                   according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMDOBIMENTS

0017   Figure 1 illustrates a projection objective 1 for
        semiconductor lithography only in part and only in
        principle, since its design is fundamentally known. The
        objective 1 has a multiplicity of lenses 2 which are
        connected to the objective via frames or holders 3.

0018   The interior of the objective is closed with respect to
        the external surroundings, or at least largely .ealed
        off, a plurality of individual internal spaces 4 being
        present as a rule between the lenses 2. The internal
        spaces 4 are under a slight overpressure and are
        flushed via very small bores 5, bores 5a constituting
        inlet openings and bores 5b outlet openings.

0019   The flushing can be carried out very generally in the
        following way:

0020   The flushing can be performed by a gas mixture composed
        of nitrogen with a volumetric fraction of 98.8% and
        helium as inert gas with a volumetric fraction of 1.2%.
        If appropriate, the use of another inert gas instead of
        helium is also possible, in which case the composition

must then, of course, be changed appropriately in order to produce overall a refractive index in the internal spaces 4 which corresponds to that of air, for which the objective 1 was calculated.

0021   The calculation for the purpose of matching the refractive index of the gas mixture of nitrogen and helium for the purpose of adaptation to the refractive index of air is performed in accordance with the following formula:

$$N_{mix} = n_1{}^*q_1 + n_2{}^*q_2$$

where $q_1 + q_2 = 1$. N_{mix} : is the refractive index of the mixture; n_1, n_2 is the refractive index of Gas_1 or Gas_2, respectively; and q_1, q_2 : is the fraction of Gas_1 or Gas_2, respectively.

0022   Air is understood as a composition of nitrogen and oxygen which can, of course, fluctuate inside a certain range within the scope of the invention. This means that the expression "air" used in the application signifies in a very general way compositions resembling air. Thus, for example, synthetic air can be used as air, the fraction of nitrogen being between 78 and 80% by volume, and the fraction of oxygen between 20 and 22% by volume.

0023   Concrete exemplary embodiments are specified below of a wavelength which is specified merely by way of example. The refractive index data relates in each case to a temperature of 22°C and a pressure of 950 mbar. The refractive indices which relate to other temperatures and pressures can be converted with the aid of the formula of Lorentz-Lorenz (see, for example, M. Born, E. Wolf, Principles of Optics, 6th edition, (Pergamon, London 1980), pages 87-98).

1) Replacement of air at 248.4 nm by a nitrogen-helium mixture:

0024   the mixing ratio is calculated as 1.36% helium with 98.64% nitrogen from the refractive indices for dry air with 79.5% by volume of nitrogen (N) and 20.5% by volume of oxygen (O_2) in accordance with the refractive indices of air after F. Kohlrausch, Praktische Physik, [Practical Physics], volume 1, section 5.1.1.2.3, (B. G. Teubner, Stuttgart, 1968) of 1.0002763, for nitrogen in accordance with the refractive indices of nitrogen after U. Griesmann, J. H. Burnett, "Refractivity of nitrogen gas in the vacuum ultraviolet", OPTICS LETTERS, Vol. 24, No. 23 (December 1999) of 1.0002797, and for helium in accordance with the refractive indices of helium after R. Abjean, A. Mehu, A. Johannin-Gilles, "Mesure interferometrique des indices de refraction de l'helium et du neon dans l'ultraviolet", [Interferometric measurement of the refracted indices of helium and neon in the ultraviolet"], C. R. Acad. Sc. Paris, t271 (19 Oct 1970) - Series B - 835 of 1.0000314.

2) Replacement of synthetic air at 248.4 nm by a nitrogen-helium mixture:

0025   a) synthetic air with 80% nitrogen and 20% oxygen:
the refractive index of the synthetic air (80% N_2, 20% O_2) is obtained as 1.0002766 from the refractive indices for nitrogen in accordance with the finding as at 1), refractive indices for nitrogen of 1.0002797 and for oxygen in accordance with the refractive indices of oxygen after R. Ladenburg, G. Wolfsohn, Z. Phys. 79 [1932], 42/61, 53, of 1.0002642. The mixing ratio of the replacement mixture is calculated as 1.24% helium with 98.76% nitrogen with the aid of the refractive index for helium in accordance with the finding as for 1) of 1.0000314.

b)   synthetic air with 78% nitrogen and 22% oxygen: the refractive index of the synthetic air (78% N_2, 22% O_2) is obtained as 1.0002763 from the refractive indices for nitrogen in accordance with the finding as for 2a) of 1.0002797, and for oxygen in accordance with the finding as 2a) of 1.0002642. The mixing ratio of the replacement mixture is calculated as 1.37% helium with 98.63% nitrogen with the aid of the refractive index for helium in accordance with the finding as for 1) of 1.0000314.

0026   Another nitrogen-inert gas mixture is to be provided if appropriate in the case of other wavelengths. This holds, for example, for replacement of (synthetic) air at 193 nm. Krypton and xenon, for example, can be used in this case as alternative inert gasses instead of helium.

0027   Projection objectives for semiconductor lithography frequently change their imaging characteristics during operation or transportation. These characteristics must therefore be corrected from time to time by means of mechanical manipulators. If a specific inhomogeneous flushing is now undertaken of one or more air spaces, largely sealed off from the remainder of the objective, with the aid of gasses of different refractive indices, it is possible, as the case may be, to dispense with mechanical manipulators. For this purpose, nozzles arranged in an appropriate distribution on the circumference can spray different gasses into the air space of the objective. Depending on the gasses introduced, this results, in a fashion distributed over the circumference, in different refractive indices of the gasses in accordance with different local refraction regions in the air or gas space. These locally differing refraction regions are a function in this case of the position and direction of inflow of the gasses. Thus, for example, there are produced in the vicinity of the nozzle area of a specific gas

regions which correspond to the refractive index of the
inflowing gas, while in another regions corresponding
mixtures with a further gas or else with a plurality of
other gasses are present, resulting correspondingly in
other refractive index in this region. Aberrations
during operation of the projection objective can be
manipulated in this way, the result being effects which
correspond to the action of z- and x-/y- manipulators
or an active lens.

0028   A precondition for this is, of course, that during
operation a stationary or at least quasi-stationary
operation is set up, or that correspondingly
reproducible regions are produced in the gas space with
a constant gas composition so that reproducible ratios
are produced with reference to the correction of
imaging characteristics. This means that it must be
possible to represent specific, stable mixing gradients
of the gasses in the closed gas space.

0029   This means in design terms that the inlet openings 5a
and outlet opening 5b illustrated in figure 1 are to be
arranged distributed correspondingly over their
circumference of the objective 1, and that locally
differing gasses are to be introduced via the inlet
openings.

0030   Figure 2 is a schematic of a protection exposure
machine having a projection objective 1 in accordance
with the illustration in figure 1. Since the projection
exposure machine in accordance with the exemplary
embodiment is known in principle, see, for example,
DE 100 02 26 A1, this design will be examined only
briefly below. It comprises a light source 6, an
illuminating system 7, a structure mask 8 also termed
reticle, the projective objective 1, which is designed
as a reduction objective, and an object to be exposed,
specifically a wafer 9. An excimer laser, for example,
can be used as light source 6. Provided in the

illuminating system 7 are optical components for beam shaping, for beam homogenization and for correct illumination of the structure mask 8 and the projection objective 1. The object to be exposed can be a silicon wafer 9 coated with photoresist.